

BELLCOMM. INC.

SATURN V  
DATA LINK EVALUATION  
(Progress Report)

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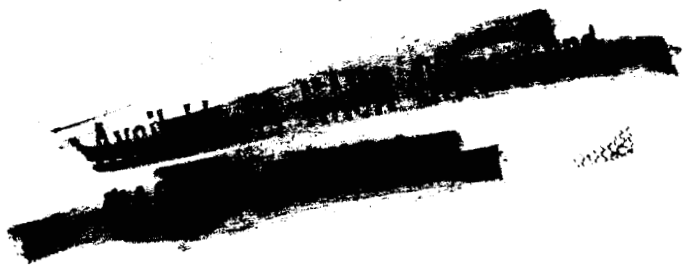


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FIGURE 1

SATURN V DATA LINK EVALUATION  
(PROGRESS REPORT)

1.0 INTRODUCTION

This is the first in a series of progress reports on the Saturn V data transmission system design evaluation undertaken by Bellcomm. It outlines the activities undertaken to date, current impressions of system status, apparent and potential problem areas, and future work to be done. The viewpoints presented are necessarily to be considered preliminary. As the study continues, more definitive positions will doubtless be adopted until the project culminates in a final report.

2.0 PRELIMINARY ACTIVITIES

The study was begun during the first half of the month of July, following the contract clarification meeting at NASA Headquarters in Washington, D.C., July 7, 1964, and attended by representatives from NASA Headquarters (Messrs. J. F. Underwood, R. V. Murad, and T. A. Keegan), NASA-MSFC (Messrs. F. Wojtalik and J. Lewis), and Bellcomm, Inc. (Messrs. C. M. Klingman and E. L. Gruman). The accumulation and assimilation of background material has occupied the major portion of time given to the project so far.

Three information gathering trips were made during July:

- (1) A one day trip to Huntsville, Alabama, for background material and a breadboard facility briefing.
- (2) A two day trip to Bell Telephone Laboratories in New Jersey for review discussions of state-of-the-art cable making practices and data terminal design techniques.
- (3) A three day trip to RCA Communications System Division at Tucson, Arizona, for a preliminary design review of the Saturn V data modems.

The Huntsville and Tucson trips resulted in the accumulation of a considerable body of project documentation in addition to the quantity of verbal information communicated. The Bell Laboratories trip produced some sound guidelines for what can be expected from current hardware production techniques.

### 3.0 BASIC JOB

The evaluation portion of the task being undertaken divides rather naturally into two somewhat separate jobs:

- (1) A hardware design evaluation of the proposed data terminals currently undergoing development, and
- (2) An evaluation of the alternative methods available for implementing the interconnecting composite communication cables.

These two jobs tend to separate somewhat from one another because the data terminal cable requirements are not only a function of the system for which the cable is provided but also, to some extent, a function of the aggregate of cable requirements from various other communication systems. Consequently, a broader context of ground rules is applicable to the cable design than is applicable to the data terminal design. In like manner, the acceptance test requirements portion of the task being undertaken will divide into these two more-or-less separate parts, and these must necessarily follow in time the evaluation portion of the task.

The principal output from a design evaluation such as this current effort, is to give some measure of system suitability in the light of system requirements. This can be done, of course, only to the extent that requirements are sharply defined. Sharply defined technical requirements are rarely available at the beginning of a project, and consequently a design evaluation usually involves, to some extent, an assessment of the evolving system requirements which are influencing areas of prime concern, such as reliability, cost, and scheduling. It should be recognized that establishing system requirements is not the responsibility of a design evaluation; however, comments upon requirements in view of hardware design complexities and costs are quite proper in giving direction to the evolution process.

### 3.1 BIRDS-EYE SYSTEM DESCRIPTION

The system under consideration is most easily described by a simple block diagram such as Figure 1, attached. The two blocks labeled 110A, CPU represent the RCA-110A checkout computers. The two blocks labeled IODC represent the special input-output data channels which provide the required electrical interface between the transmission terminals and the computers. These four blocks are external to the transmission system under consideration.

### 3.2 INITIAL SYSTEM EVALUATION

The data terminals are being designed for 250 kb/s transmission, with an information rate of 130 kb/s, using the RCA modified diphase modulation scheme. The transmission bandwidth used is 400 kc and the highest frequency transmission loss over the maximum distance of seven miles of cable is approximately 41 db. The initial signal transmission level is 26 dbm which, neglecting margins and coupling losses for the moment, gives a nominal high frequency signal level of approximately (-)15 dbm at the receiving input to the system. These basic items of data are the result of a situation not often found in commercial transmission system practice, for here there is no unusually great premium to be put on bandwidth conservation (Hence, the information transfer efficiency of  $130/250 = 0.52$  is quite acceptable), and convenient signal working levels are well above the predictable noise levels, to the point that even a repeatered cable is not desirable.

The use of diphase modulated transmission via a hardline appears to be a reasonable choice among the methods available for accomplishing the basic data transfer job. Relative to alternative transmission schemes employing AM, FSK, or PSK, the diphase scheme promises not only highly competitive error performance characteristics for a given S/N ratio, but has the additional merit of requiring relatively simple terminal equipment -- a feature potentially having desirable cost and reliability implications. While no system exactly identical to the one presently being developed has been designed previously, the circuit designs employed appear to be straightforward, and many are simple extrapolations from a similar system tailored to a different data rate. Meeting the basic technical requirements for the data transfer job does not appear, at least conceptually, to be a formidable job per se. The more difficult aspect of the overall job will be to produce the working hardware with reliable performance characteristics within schedule limitations.

The interconnecting transmission line specified for the data terminals is a standard design, balanced video pair and is a logical choice for the job. Just what is the most judicious method for installing this line between cable distribution points is a matter open to some question at present because of cost versus reliability considerations. The cost-reliability trade-off is influenced by a number of factors which are presently supported by speculation as much as fact, such as the degree of mechanical and electrical cable protection to be employed, the amount of splicing which is tolerable, installation costs, and crosstalk effects. The breadboard facility at Huntsville, which will use buried Minuteman-sheath cable for initial testing and simulation, will supply additional information to the tentative evaluations made thus far, and provide a better technical basis than now exists for a decisive judgment about the KSC installation.

### 3.3 RELIABILITY

Experienced people tend to agree that reliability is achieved through:

- (1) Conservative practices in all phases of design
- (2) Employing high quality components in a carefully controlled production program; and
- (3) Using the system within the restrictions for which it was designed to be used.

All three of these things must be taken together. While comparisons of failure rate numbers can be very useful, they are usually so only within rather strict limitations.

As previously implied, the data transmission system at hand has a certain freedom from the usual commercial design constraints and this permits the possibility of conservative design practice in one of the most vital system performance areas, which is adjusting bit error rate as a function of signal-to-noise ratio. Working at relatively high signal levels is an effective means of combatting the effects of noise. To a reasonably gratifying extent, the system does this. Also, a certain amount of conservative design has been used in the data transmission format. The two dimensional parity check for word error detection is a reasonable choice among the possible alternative coding schemes available and the associated word

error correction by retransmission is simple and effective, noting that the complexities of alternative schemes far outweigh their advantages. Conservative practices in design, of course, must extend into the basic electronic circuits themselves, as well as the ways in which they are used. No cause for alarm in this area has been observed in the data terminals to date, although an eye is being kept on a few special developmental circuits (the pulse-locked oscillator and the input coupler in the modem) having strict performance requirements.

Component quality in the data terminals is comparable to the 110A computer component quality, and this appears acceptable in the light of related measures being taken (switch-over redundancy) for reliable system configuration operation.

The principal concerns with cable reliability have to do with distribution points, connection points and splice points -- those places where human handling and patching of the conductors occurs. Splicing must be lived with due to the practical limitations of highly expensive cable-making machinery. So must distribution and connection points. However, Bell System experience in video transmission indicates that these potentially unreliable areas need not be troublesome if appropriate cautions are exercised in the installation processes. The key, of course, is insuring good workmanship.

#### 4.0 APPARENT AND POTENTIAL PROBLEM AREAS AND FUTURE WORK

Areas in the data terminal design which appeared to have room for some improvement are:

- (1) Transient overload protection of receiver input circuitry
- (2) Lightning protection of the transmitter portion of the terminal; and
- (3) Pre-amplifying the receiver input signal prior to equalization.

RCA has the first two points under consideration, although the third is yet to be discussed with them. There is no cause for alarm on these points, as these types of deficiencies are a normal part of a development and, once noted, usually become corrected almost as fast as they appear.


Potential problem areas with the cable involve the grounding policies for signal leads, signal-lead shielding, and overall cable shielding. The preliminary judgment on this matter

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is that separate, one-end floating grounds should be used. Signal lead shielding of distribution and connection points must be spelled out in detail to prevent the coupling of noise and crosstalk into the system. Then, the matter of deciding what adequately constitutes conservative engineering practice in the specification of a composite cable must be determined and agreed upon. There is serious question, for example, about the value of using a conductive-type outer sheathing. Also, the lightning and mechanical protection capabilities of some commercial communication cable, such as the double shielded (aluminum, steel) PASP-type design, merit comparison with minuteman cabling.

During the next reporting period specific attention will be given to the areas just mentioned. The work to be done will involve mostly the analysis of information already accumulated, although the detailing of specific configuration information from RCA, KSC, and MSFC must also continue.

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# BIRDS-EYE SYSTEM DESCRIPTION

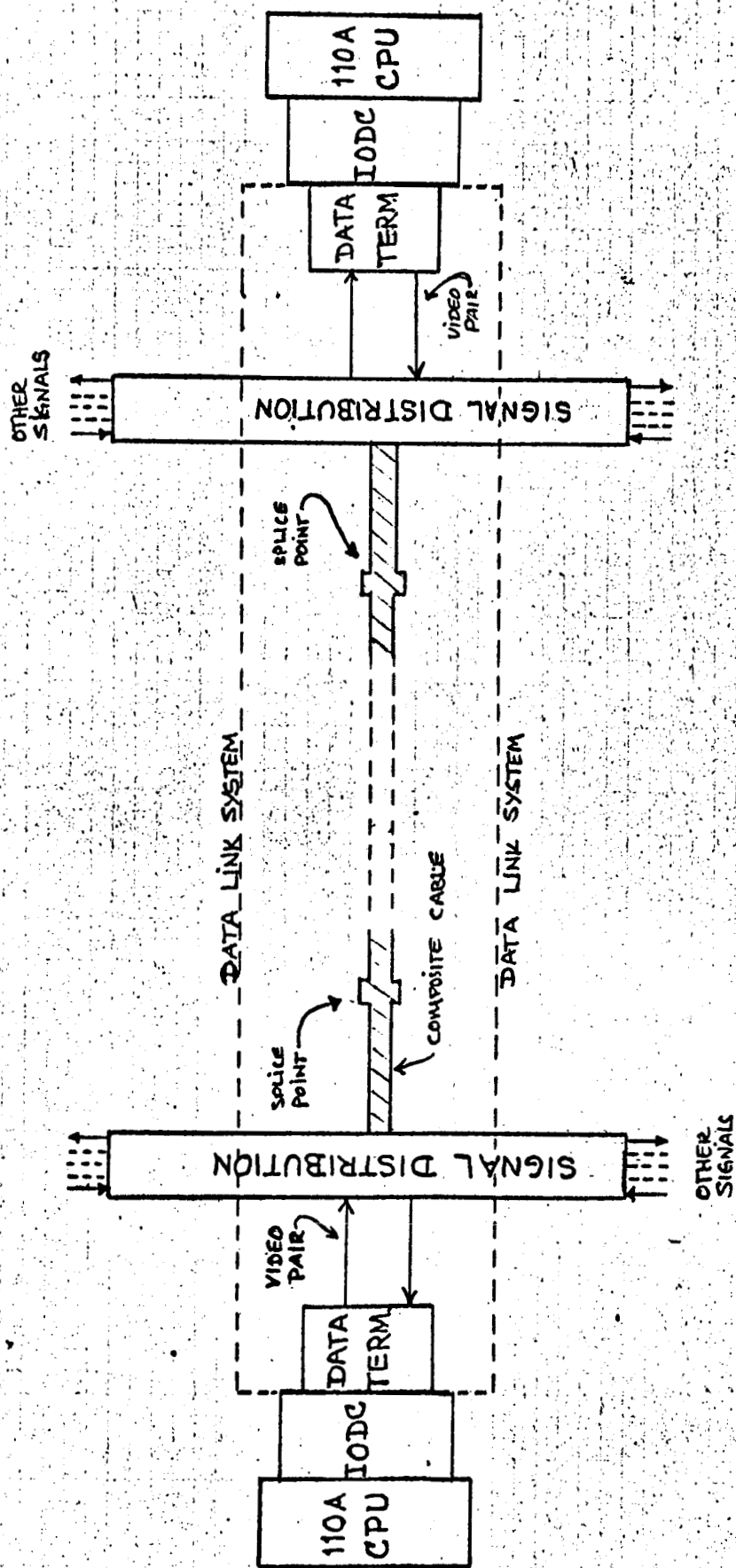


FIGURE 1-A